

I Claim:

1. A characteristic evaluation method for insulated gate type transistors, comprising:
 - a) preparing at least two insulated gate type transistors including first and second insulated gate type transistors that differ from each other only in mask channel width;
 - b) extracting a threshold voltage of said first transistor that has a mask channel width larger than that of said second transistor, estimating a threshold voltage of said second transistor, and employing a value of the estimated threshold voltage as a first estimated value;
 - c) when a difference between a gate voltage of said first transistor and said extracted threshold voltage of said first transistor is defined as a first gate overdrive, a difference between a gate voltage of said second transistors and said first estimated value is defined as a second gate overdrive, and an X-Y plane is assumed whose X-axis is said mask channel width and Y-axis is source-drain conductance, (i) extracting a virtual point at which a change of Y coordinate value is estimated to be approximately zero even if said first and second gate overdrives are finely changed, from a characteristic curve exhibiting a relationship between said mask channel widths of said first and second transistors and said source-drain conductance, (ii) defining values of an X coordinate and a Y coordinate at said virtual point as second and third estimated values, respectively, and (iii) extracting a slope of said characteristic curve at said virtual point and employing a value of the extracted slope as a fourth estimated value;
 - d) repeating said step c) while varying said first estimated value;
 - e) after said steps c) and d), (i) finding, from said second to fourth estimated values, optimum second to fourth estimated values with which the change of said third estimated value is equal to a product of the change of said second estimated value and said fourth estimated value, in reply to fine changes of said first and second gate overdrives, (ii)

determining an optimum first estimated value that corresponds to said optimum second to fourth estimated values, and (iii) determining a true threshold voltage of said second transistor based on said optimum first estimated value; and

f) determining a difference between said mask channel width and an effective channel width, based on said true threshold voltage.

2. The method of claim 1, wherein in said step e), said characteristic curve is approximated by using a first straight line in said X-Y plane, said first straight line passing through a first point that is given to said first transistor when said first gate overdrive has a first value and a second point that is given to said second transistor when said second gate overdrive has said first value.

3. The method of claim 2, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = dW^{**}(\delta, V_{gtWi}) + \frac{f(\delta, V_{gtWi})}{f'(\delta, V_{gtWi})} \cdot dW^{**'}(\delta, V_{gtWi}) - DW^*(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; dW^{**} is a value of an X intercept that is obtained by extrapolating said characteristic curve; f is said slope of said characteristic curve at said virtual point; DW^* is an X coordinate value at said virtual point; and a prime is a first-order differentiation of V_{gtWi} .

4. The method of claim 2, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = \frac{f^2(\delta, V_{gtWi})}{f'(\delta, V_{gtWi})} \cdot dW^{**'}(\delta, V_{gtWi}) - G_m^*(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; dW^{**} is a value of an X intercept that is obtained by extrapolating said characteristic curve; f is said slope of said characteristic curve at said virtual point; G_m^* is a Y coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

5. The method of claim 2, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = G_m^{**}(\delta, V_{gtWi}) - \frac{f(\delta, V_{gtWi})}{f'(\delta, V_{gtWi})} \cdot G_m^{**'}(\delta, V_{gtWi}) - G_m^*(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; G_m^{**} is a value of a Y intercept that is obtained by extrapolating said characteristic curve; f is said slope of said characteristic curve at said virtual point; G_m^* is a Y coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

6. The method of claim 2, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = \frac{G_m^{**'}(\delta, V_{gtWi})}{f'(\delta, V_{gtWi})} + DW^*(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; G_m^{**} is a value of a Y intercept that is obtained by extrapolating said characteristic curve; f is said slope of said characteristic curve at said virtual point; DW^* is an X coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

7. A characteristic evaluation method for insulated gate type transistors, comprising:
- a) preparing at least two insulated gate type transistors including first and second insulated gate type transistors that differ from each other only in mask channel width;
 - b) extracting a threshold voltage of said first transistor that has a mask channel width larger than that of said second transistor, estimating a threshold voltage of said second transistor, and employing a value of the estimated threshold voltage as a first estimated value;
 - c) when a difference between a gate voltage of said first transistor and said extracted threshold voltage of said first transistor is defined as a first gate overdrive, a difference between a gate voltage of said second transistors and said first estimated value is defined as a second gate overdrive, and an X-Y plane is assumed whose X-axis is said mask channel width and Y-axis is source-drain conductance, (i) extracting a virtual paint at which a change in Y coordinate value is estimated to be approximately zero when said first and second gate

overdrives are finely changed, from a first characteristic curve exhibiting a relationship between said mask channel widths of said first and second transistors and said source-drain conductance, and employing a value of an X coordinate at said virtual point as a second estimated value or (ii) employing a value of an X intercept of said first characteristic curve as said second estimated value;

d) repeating said step c) while varying said first estimated value;

c) after said steps c) and d), (i) finding, based on said first and second estimated values, an optimum first estimated value with which a second characteristic curve exhibiting a relationship between said second gate overdrive and said second estimated value in an X-Y plane whose X-axis is said second gate overdrive and Y-axis is a value related to said second estimated value, has a predetermined shape within a predetermined range of said second gate overdrive, and (ii) determining a true threshold voltage of said second transistor based on said optimum first estimated value; and

f) determining a difference between said mask channel width and an effective channel width based on said true threshold voltage.

8. The method of claim 7, wherein

in said step c), said value of the X intercept of said first characteristic curve is defined as a third estimated value, and

in said step e), a value that is obtained by reducing said second estimated value from twice said third estimated value is employed as said value related to said second estimated value.

9. The method of claim 8, wherein in said step e), said first estimated value with which a value that is obtained by reducing said second estimated value from twice said third estimated value is best converged on a fixed value in said predetermined range is employed as said optimum first estimated value.

10. The method of claim 8, wherein in said step f), a difference between said mask channel width and an effective channel width is determined from a value that is obtained by reducing said second estimated value from twice said third estimated value when said gate overdrive is in a vicinity of 0 V.

11. A characteristic evaluation method for insulated gate type transistors, comprising:

- a) preparing at least two insulated gate type transistors including first and second insulated gate type transistors that differ from each other only in mask channel width;
- b) extracting a threshold voltage of said first transistor that has a mask channel width larger than that of said second transistor, estimating a threshold voltage of said second transistor, and employing a value of the estimated threshold voltage as a first estimated value;
- c) when a difference between a gate voltage of said first transistor and said extracted threshold voltage of said first transistor is defined as a first gate overdrive, and a difference between a gate voltage of said second transistors and said first estimated value is defined as a second gate overdrive, (i) under a condition that said first and second gate overdrives are equal in an X-Y plane whose X-axis is said mask channel width and Y-axis is source-drain conductance, extracting a virtual point at which a change in Y coordinate value is estimated to be approximately zero even if said first and second gate overdrives are finely changed, from points on a straight line passing through a first point whose X coordinate is said mask

channel width of said first transistor and Y coordinate is said source-drain resistance of said second transistor, and a second point whose X coordinate is said mask channel width of said second transistor and Y coordinate is said source-drain resistance of said first transistor, (ii) defining values of the X coordinate and Y coordinate at said virtual points as second and third estimated values, respectively, and (iii) extracting a slope of said straight line at said virtual points and employing a value of the extracted slope as a fourth estimated value;

d) repeating said step c) while varying said first estimated value;

e) after said steps c) and d), determining a true threshold voltage of said second transistor by using said first to fourth estimated values; and

f) determining a difference between said mask channel width and an effective channel width, based on said true threshold voltage.

12. The method of claim 11, wherein said step e) comprises: (i) finding, from said second to fourth estimated values, optimum second to fourth estimated values with which a change of said third estimated value is equal to a product of a change of said second estimated value and said fourth estimated value, in reply to fine changes of said first and second gate overdrives; (ii) determining an optimum first estimated value that corresponds to said optimum second to fourth estimated values; and (iii) determining the true threshold voltage of said second transistor, based on said optimum first estimated value.

13. The method of claim 12, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = \frac{h^2(\delta, V_{gtWi})}{h'(\delta, V_{gtWi})} \cdot dW^{**'}(\delta, V_{gtWi}) - R^{\#}(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; dW^{**} is a value of an X intercept that is obtained by extrapolating said straight line; h is said slope of said straight line; $R^{\#}$ is a Y coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

14. The method of claim 12, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = R^{**}(\delta, V_{gtWi}) - \frac{h(\delta, V_{gtWi})}{h'(\delta, V_{gtWi})} \cdot R^{**'}(\delta, V_{gtWi}) - R^{\#}(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; R^{**} is a value of a Y intercept that is obtained by extrapolating said straight line; h is said slope of said straight line; $R^{\#}$ is a Y coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

15. The method of claim 12, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = \frac{R^{**}(\delta, V_{gtWi})}{h'(\delta, V_{gtWi})} + DW^{\#}(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; R^{**} is a value of a Y intercept that is obtained by extrapolating said straight line; h is said slope of said straight line; $DW^{\#}$ is an X coordinate value at said virtual point; and a prime is the first-order differentiation of V_{gtWi} .

16. The method of claim 12, wherein in said step e), said optimum second to fourth estimated values are determined from a relational expression:

$$F(\delta, V_{gtWi}) = dW^{**}(\delta, V_{gtWi}) + \frac{h(\delta, V_{gtWi})}{h'(\delta, V_{gtWi})} \cdot dW^{**}(\delta, V_{gtWi}) - DW^{\#}(\delta, V_{gtWi})$$

where δ is a difference between the first estimated value and the threshold voltage of said first transistor; V_{gtWi} is said first gate overdrive; dW^{**} is a value of an X intercept that is obtained by extrapolating said straight line; h is said slope of said straight line; $DW^{\#}$ is an X coordinate value at said virtual point; and a prime is a first-order differentiation of V_{gtWi} .

17. The method of claim 11, wherein said step e) comprises: (i) finding, an optimum first estimated value with which a characteristic curve exhibiting the relationship between said second gate overdrive and said second estimated value has a predetermined shape in a

predetermined range of said second gate overdrive in an X-Y plane whose X-axis is said second gate overdrive and Y-axis is said second estimated value; and (ii) determining the true threshold voltage of said second transistor, based on said optimum first estimated value.

18. The method of claim 17, wherein said step e) comprises estimating an optimum characteristic curve with which said second estimated value is best converged on a fixed value in said predetermined range, from said characteristic curve in plural.

19. The method of claim 11, wherein in said step f), a difference between said mask channel width and an effective channel width is determined from said second estimated value when said gate overdrive is in a vicinity of 0 V.